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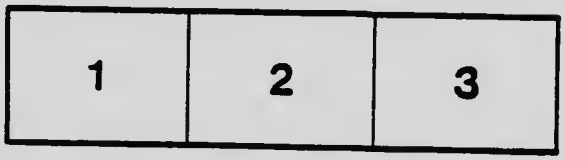

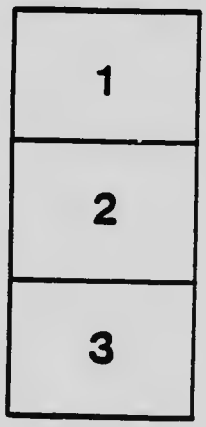

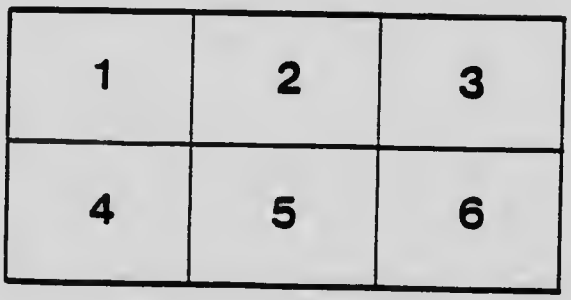

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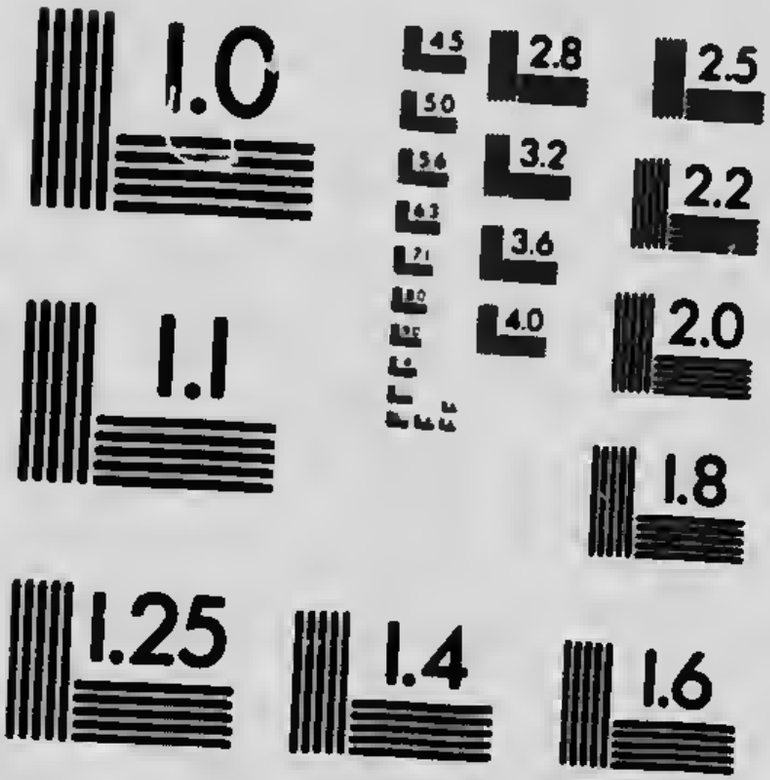

Transactions of The Royal Society of Canada
SECTION III

SERIES III JUNE 1916 VOL. X

PRESIDENTIAL ADDRESS

Agricultural Education and Research in Canada

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(Delivered May 17th, 1916.)

For the purpose of this address our subject may be discussed under three headings: The Status of Agriculture in Canada, The Value of Science in Agriculture, and the Improvement of the Practice of Agriculture in Canada through Education, Demonstration and Research.

The Status of Agriculture in Canada

In order that we may properly appreciate the importance of research in agriculture in this country it is first necessary that we should understand the position of agriculture among the industries of the Dominion.

It is not too much to say that agriculture is Canada's basic and most valuable industry, the industry above all others for which the country as a whole is best adapted, the industry employing the most men and that creates more wealth annually than all our other industries put together. It has been the pioneer occupation of our people and it will remain, I believe, the staple business of our people. Upon its economic development and progress depends in a very large measure the welfare and prosperity of our national life.

To those whose lives and work are cast among the varied and important activities of one of our larger centres, these statements regarding the status and importance of agriculture may appear somewhat strange and perhaps overdrawn, but I am confident that they will, in the main, be confirmed by those who have studied the life and work of the Dominion as a whole and its natural resources, and more especially by those who know Canada by actual travel. It is

not my purpose to burden this address with statistics, but to place before you some facts in confirmation of my contention, I have asked Mr. Ernest H. Godfrey of the Dominion Census and Statistics Office for certain data bearing on my subject. He has very kindly responded and I shall now read the paragraphs that he has prepared.

"*Number of Persons dependent upon Agriculture.* The total population of Canada, as returned at the Census of 1911, was 7,206,643. Of this total 3,925,679, or about fifty-four per cent, was classified as rural. The number of persons engaged in or dependent upon agriculture in Canada may safely be placed at about fifty-five per cent of the total.

"*Land in Canada capable of devotion to Agriculture.* Varying estimates have been made from time to time as to the extent of land in Canada that can be devoted to agriculture out of the total land area of Canada, which is placed at 2,306,502,400 acres. Without including the areas outside of the nine provinces as at present constituted, a moderate estimate, based upon census data, is that 440,951,000 acres is possible of cultivation as farm land. (See Year Book, 1914, p. 208). The total area of land now within the boundaries of the nine provinces is 1,401,316,413 acres. Of this area 109,948,988 acres, or less than eight per cent, were returned at the Census of 1911 as in occupation as farm land.

"If, however, we confine attention to land within the provinces that is more immediately available for settlement, we find that altogether there are just under sixty million acres, consisting of about twenty-eight million acres of the Dominion Public Lands open to homestead entry, and about 31,800,000 acres of the Provincial Public Lands available for agricultural settlement.

"The occupied farm lands referred to, viz., 109,948,988 acres are divisible into improved lands, 48,733,823 acres and unimproved land 61,215,165 acres; so that adding this latter total to the 59,800,000 acres of public lands awaiting settlement, we get a total of about 120,000,000 acres of land capable of almost immediate application to agriculture.

"*Value of Agricultural Production.* In 1915 the field crops of Canada were valued at about $800,000,000, but this was an exceptional year as regards yield, and the average annual value is more nearly $650,000,000. If we add to this figure the estimated value of farm live stock, say $750,000,000, we get a total of $1,400,000,000 as the total value of the annual agricultural production of Canada. This figure does not include dairying products. In 1910 the total value of the butter and cheese production of Canada was returned as about $69,500,000. The value of agricultural production,

relatively to other products of Canada, may be gathered from the following statements of the average total values of products in thousands of dollars.

Products	Value	Per cent of total
	Thousand dollars	p.c.
Agriculture	1,400,000[1]	47
Dairying	70,000	2
Forestry, (including skins and furs of wild animals)	177,000	6
Fisheries	33,000	1
Mines	130,000	4
Manufactures	1,200,000	40
Total	3,010,000	100

"This statement shows that the value of agricultural and dairying products taken together, amounts to about fifty per cent of the total, whilst it must be remembered that with regard to manufactures, which account for forty per cent of the total, there are included substantial values for numerous items of raw materials which also come under the heading of agricultural products."

These statistics, I think you will agree with me, amply testify that my statements with regard to the position that agriculture holds in the Dominion are not exaggerations, but the plain and sober truth.

If then we are agreed on this point, it will be obvious that all reasonable effort should be made to encourage and assist this national industry, by the education in agricultural matters of those upon the land and of those who will be the future farmers of our country, by practical demonstrations of methods of proven worth and by investigation to advance our knowledge in the science of agriculture and establish principles of fundamental importance and wide application. It is a matter of national congratulation that our governments, Federal and Provincial, have recognized their responsibilities and opportunities in this connection and have given in recent years gener-

[1] This includes the total value of farm livestock in Canada on December 31st, 1915, and therefore this figure involves a certain error, since it has been obtained by adding together field crop production and livestock capital. The annual increase in livestock value is not obtainable and this fact adds largely to the difficulty always experienced in estimating the total net annual production of Canadian agriculture.

ously for the establishment and carrying on of the several agencies which work for the improvement of agriculture. In this our governments may be said to have vied with one another with a result that Canada, considering her revenue, is probably to-day outdone by no country in the world in the maintenance of institutions and agencies for the education of the farmer. Later in this address we shall attempt an enumeration of these agencies, but it may be noted here that the number of our Agricultural Colleges has increased very considerably in recent years and that Provincial Institutions of first importance are constantly increasing in their efficiency and adding to their teaching staffs and equipment. They are undoubtedly doing a most valuable educational work and are steadily widening and emphasizing their influence upon the practical farming of the Dominion.

Though agriculture is not a science in the same sense that chemistry, biology and physics are sciences, there is in a very real and vital sense a science of agriculture in which the basic sciences I have named and others are called upon to contribute towards the solution of problems affecting farming and to establish the truths which must furnish the foundation necessary for the rational conduct and development of the art. To elaborate this thought somewhat: It is evident, in the first place, that agriculture is a vocation or occupation whereby men earn a livelihood and in which they till the soil, sow and harvest crops, feed and raise livestock. It is an art or craft, therefore, requiring skill and experience in manipulation for its successful prosecution. It is obvious that above all the farmer is a director of agencies (for he himself creates nothing), agencies which involve the life of the soil, the life of plants, the life of animals. He ought to know how these agencies may best be directed and controlled. From this view, and I believe it is the correct one, the science of agriculture, as supplying the basis for all this work, is very largely a sub-division of our latest development in pure chemistry, bio-chemistry; I say largely, for it is not exclusively bio-chemistry; physics, meteorology, economics and other sciences must be called upon in the attempt to establish the truth and to mark the way for further progress in the art of farming.

Considering the ages that it has been practised, the art of agriculture has unaided by science made but very slow progress. Ignorance of the nature of the factors involved, nay more, that there were any factors beyond those that were absolutely obvious and self evident, superstition, faulty observation leading to erroneous deductions, the lack of mental alertness and clear thinking in tracing out cause and effect—which in the past have so peculiarly characterized those engaged on the land—the habit of mind and life that may be

considered as a kind of conservatism to the methods of the past and almost an antagonism to change and which has largely arisen in a most natural way from the fact that the art or practice of farming has been handed down from father to son; to these and, perhaps, other causes may be attributed the fact that agriculture unaided by science made but little progress for centuries.

With the application of science to agriculture another day dawned. So recent is this day that the pioneers—first chemists, next biologists, finally physicists—have but passed from their labours in our own times. This brings home to us how very new is this field of research; compared with the application of science to metallurgy, for instance, it is a matter of yesterday. Nevertheless, the teachings of this new science have already exerted a beneficial influence. Throughout the civilized world the response has been rapid and prompt and the practice of farming has so improved in many of its phases—indeed we may say almost revolutionized—that it is scarcely recognizable as that of our fathers. This is most encouraging, not only to those engaged on the problems of agriculture, but to the state at large, for it means greater economy in work, a better conservation of our resources and the placing of agriculture upon a more intelligent and profitable basis. It means, above all, the raising of the whole status of farming, so that in the near future it will stand side by side with professions and callings that have hitherto been considered its superior. It is due to the teachings of science that our soils are more productive, that our yields are heavier, that our crops are more prolific and more nutritive, that our cows give more and richer milk, that our hens lay more eggs than half a century ago. The point I wish to emphasize is that the marked improvement in farming as an industry in recent years is due very largely to the abandonment of haphazard, rule-of-thumb methods and the adoption of methods based on the results of carefully, skillfully conducted investigation by chemists, botanists, physiologists, physicists, entomologists and other scientists. Rational, profitable farming to-day has scientific truths for its foundation.

It is not my purpose in this address to attempt any chronological account of the history of what may be termed agricultural science. Interesting and fascinating as this history is, the story is too long. Nor shall I burden this address with any detailed account of Canada's contribution to this science. Three years ago, in an address before the Royal Canadian Institute of Toronto, I outlined the various investigations that had been undertaken by the Dominion Experimental Farm system—Canada's chief agricultural research institution—during the twenty-five years of its existence, and endeavoured by a number of examples to show the practical results that might legitimately be

considered as the outcome and natural sequence of this Canadian work. Copies of this paper and the larger number of the reports and bulletins of the Experimental Farms, which give fuller details of the work, are still available for those interested in the subject.

Value of Science in Agriculture

It may serve to emphasize our contention that practical agriculture is influenced for good by scientific research and, further, bring home to us the benefit that is accruing therefrom if we recite one or two concrete examples of the applications of scientific discovery to the practice of farming.

One of the most interesting and basic in its influence is the appropriation of nitrogen by the leguminosae. The ancients were aware that clover in some way enriched the soil, for we find it recorded in Roman literature that a crop, say of a cereal, produced a larger yield when following clover than when following a nonleguminous crop, say of grain. This fact practically lay dormant for ages: it received no application in general farming; its significance for centuries was not realized. Probably one reason for this neglect or oversight was the difficulty frequently met with on certain classes of soils in getting a "catch" of clover, and we may here remark that following the discovery of why the legumes were soil-enrichers came the knowledge of those conditions favourable for their growth.

Chemistry was the first of the sciences to be applied to explain farming operations and to furnish the explanation of how plants and animals assimilate their food and to make clear the original sources of this food. During the nineteenth century, say from the time of Liebig, who may justly be styled the father of agricultural chemistry, chemists in England, in Germany and in France were very busy in analysing soils, crops and animals and thus as analytical methods were evolved and multiplied there accumulated a vast number of data from which theories were evolved to explain the part taken by the soil, by water and the atmosphere in plant nutrition. The larger number of the earlier theories have passed away, having been shown by subsequent work that their premises were faulty, or from the fact that the data from which they were drawn were inaccurate. With the improvement of analytical methods the data became more and more accurate.

The analyses of plants revealed the chemical elements of which they were composed; of these elements nitrogen was one. Analysis further showed, in connection with the problem we are discussing, that not only were the legumes richer in nitrogen, weight for weight

of dry matter, than plants of other orders, but the further and astounding fact that they left the soil richer in nitrogen by their growth. Where did this additional nitrogen come from? What was its source? If from the uncombined, free nitrogen of the air, in what way did the legumes appropriate it? For by this time it had been fairly well established that crops in general could only obtain the nitrogen necessary for their growth from the organized nitrogen in the soil.

Many chemists worked on this problem, prominent among whom was Gilbert of Rothamsted, England, who, with Lawes, for more than fifty years did such magnificent work in agricultural research both in the laboratory and field, and placed the whole world for all time under a debt of gratitude; for their work above that of all others has furnished the foundation of agricultural science upon which others of all nations have built and still are building. Unfortunately, Gilbert just missed the solution of the problem, chiefly through imperfect apparatus. It was a great disappointment to him. The discovery was made by Hellriegel and Wilfarth, who conclusively showed that the legumes obtained their nitrogen, or in part at least, from the nitrogen of the atmosphere, not of themselves, but through the agency of certain nitrogen-fixing bacteria in the soil, which attach themselves and reside in nodules or tubercles upon the roots of the legumes, passing on their elaborated nitrogen to their host—it appears to be a case of symbiosis—for the building up of its tissues of root, stem and leaf. Without the aid of these bacteria the legumes, like all other plants, must draw upon the nitrates of the soil for their supply of this important element. As I was in England and Germany at this time (1888), I had an excellent opportunity of learning at first hand the various steps of this discovery, which, for its far reaching effects and the practical results that have followed, must be regarded *the* agricultural discovery of the century. It is interesting to note that Gilbert subsequently repeated Hellriegel's and Wilfarth's work and confirmed their conclusions.

The next and most logical step was the preparation of cultures of these useful bacteria by the bacteriologists, and these cultures are today in extensive use for inoculating the seed and soil for the growing of legumes in districts found to be lacking in the nitrogen-fixing organisms.

A further step was the discovery by the chemists that clover and alfalfa and many other valuable legumes would not thrive in acid-reacting soil, that there was no development of the nodules in such soils. Thus was brought in the now common practice of testing the soil upon which it is wished to grow a legume and the application of lime or gound limestone to correct acidity if such be found.

I must refrain from further details of this interesting story, but I would impress upon you the important results that have accrued therefrom to our farmers. Our Canadian work has shown that from 75 to 150 pounds of nitrogen may be stored up in a season, per acre, by the more commonly used legumes, and that, if the crop is nodule-bearing, a verp large part of this is from the atmosphere. This nitrogen, if the legume is ploughed under, or that part of it in the root system if the crop is removed, becomes available through nitrification for future crops of grain, etc. Out of all this has come the adoption of a rotation in which a legume forms a part and the practice of sowing clover with the cereal crop of the rotation, a plan now common, more especially in the older parts of the Dominion, one that is proving most economic and most valuable for the up-keep of the fertility of our soils. Our average acreage yields have been steadily improving in recent years, more especially in the cereals, and I attribute this fact in a large measure to the increased growing of clover and alfalfa throughout the Dominion, a natural result from our teachings and advice on this subject.

Closely related to the above are the recent studies of the microscopic life of the soil and the relation of this life to soil fertility. This is perhaps the latest phase of agricultural research, but already most valuable results to practical farming have been obtained. Soil bacteriologists, aided by chemistry, have established that the preparation of available food—and particularly of nitrogen—from the inert, insoluble stores of the soil is the life function of bacteria. Other things being equal, we may perhaps say that the number of these useful micro-organisms per unit of soil is a measure of the soil's productiveness. It is obvious that the working out of the chemical and mechanical treatments of the soil, which will encourage the development of these organisms, is an important and valuable research.

Further, it has been lately shown from a number of carefully conducted and most thorough investigations on the life of the soil. carried out at Rothamsted, that in addition to the nitrogen-fixing and other useful bacteria there are always present other forms of life, certain protozoa, that prey on these bacteria, checking their development and hence affecting soil fertility. The valuable part of this discovery, from the practical standpoint, has been the establishment of the fact that these predatory protozoa can be kept in check by processes of "partial sterilization" of the soil, as by moderately high temperatures or the use of live steam, toluene, formaldehyde or other chemicals and thus, without any addition of plant food, fertility of the soil increased. This is an eminently practical discovery. Though as yet methods of partial sterilization are not in use on the farms,

market gardeners and green-house workers have found them very valuable. There is a great future for research work in connection with the biology of the soil.

Following the determination of the chemical constituents of plants and the establishment of the sources from which they are drawn, came the use of chemical plant foods, the so-called commercial fertilizers. Laboratory and field work showed that of the thirteen or so chemical elements entering into the composition of vegetable structures, three only—nitrogen, phosphoric acid and potash—need be considered in practical agriculture. Of the others, save occasionally lime, the soil and the air might always be depended upon to furnish an ample supply for crop needs. Out of this knowledge, the result of scientific research, has grown the use of fertilizers to increase crop production. The first of these was superphosphate, advocated and manufactured by Lawes in the earlier years of his investigations at Rothamsted. We, in Canada, have as yet done little towards ascertaining the place that fertilizers can take in economic methods of soil management, but yearly we are adding to our store of knowledge in this direction. Though we believe and teach that adherence to a rational system for the upkeep of fertility, the keeping of livestock, a proper rotation and correct methods of soil cultivation will make the farmer largely independent of these artificial and expensive forms of plant food, we also believe that with increased land values and increasing prices of labour on the one hand, and of agricultural products on the other, intensive rather than extensive farming will be practised, and with this change will come the wider and better use of fertilizers. That this use may be made with a fair expectancy of a profitable return we are now experimenting widely on various types of soils and with many classes of crops.

So far we have spoken of research work in connection with the requirements of crops; we might similarly indicate the nature of investigations to determine the requirements in the animal economy; the digestibility of the nutrients in cattle feeds are for the most part well established and this knowledge with that of the requirements of the animal for its maintenance, growth and reproduction have enabled the agricultural chemist to formulate "balanced rations"—the proportions most economic of protein, fat and carbohydrates—for maintenance, for animals expending energy in doing work, for flesh production, for milk production, etc. Although the farmer can not understand the methods by which all this knowledge has been obtained, he has learnt the significance of the terms protein, fat and carbohydrates, that feeding stuffs differ in their composition, in their digestibility and hence in their nutritive value, and all this information he can

use in compounding his rations according to his available feeds and the requirements of his several animals. The intelligent stock feeder and dairyman no longer feeds in a haphazard manner whatever there happens to be at hand, but, using the tables of data giving the composition and digestibility of fodders and feeding stuffs, he is able to supplement in correct amounts his home grown fodders with various so-called "concentrates" rich in protein and fat, thus balancing the ration. In this way he may obtain results in flesh and milk production far exceeding in point of economy and profit anything that might be possible from haphazard feeding. Modern, up-to-date farming then is directly benefiting in this important branch of the industry from scientific investigation of the most profound character, investigations calling for and necessitating the deepest, broadest knowledge of chemistry, physiology and allied sciences as well as the employment of elaborate apparatus.

In the control of injurious insects and fungous diseases which attack crops the entomologist and the mycologist have in recent years, by studying life histories and devising methods for the extermination of these pests, done a great service for agriculture. The orchardist and fruit grower of the day avails himself of these discoveries, indeed, we may say that not only are hundreds of thousands of dollars saved yearly by the employment of insecticides and fungicides, but that in many parts of the Dominion, without these means of control, profitable fruit growing would be impossible. In all this investigatory work the chemist, as may be readily understood, has his part; indeed, there are few lines of research in which chemistry does not play an important part, directly and indirectly.

These are but a few instances, briefly outlined, of the application of science to agricultural problems, given to illustrate the practical advantages that accrue from scientific investigational work. It would be impossible in this address even to epitomize the many phases of this work or to enumerate the benefits that have arisen therefrom, but they may serve to impress upon you that the progress agriculture has made in recent times is directly the outcome and product of research.

The Improvement of the Practice of Agriculture in Canada through Education, Demonstration and Research

A review of the field of work carried on by Governments for the improvement of agriculture show that such work may be readily arranged or classed under one or other of the three following headings: educational, demonstrational and investigational. These are three distinct phases and yet in certain of their features are closely related and interdependent.

Educational work in agriculture should begin in the schools of the country and especially should it have attention in rural schools. The extent to which agricultural studies should occupy the time of teacher and pupil and the best method of presenting and inculcating the principles involved in the practice of farming in these schools are problems that yet await final solution. It is very encouraging, however, to note that our educationists, in practically all our provinces, are giving this important matter their careful thought and that as a result we have witnessed in recent years a distinct progress, more particularly in connection with the so-called nature study and the establishment of school gardens.

Of the agricultural colleges and schools in Canada, I have already briefly spoken. During the last decade their number has greatly increased, a most encouraging sign, looking towards the better education of those about to go on the land and towards the supply of trained men for educational and demonstrational work in our agricultural institutions. Of the work accomplished by these colleges I shall not speak in any detail, contenting myself on this occasion with the statement that I believe that it is eminently adapted to the needs of this country and that those who have it in charge are for the most part well cognizant of the character of education required by the sons of our farmers and are fully competent and qualified to impart it.

A phase of educational work that has been specially developed in Canada and which has proven most valuable is teaching by correspondence, the supplying through the mails, in response to individual requests, of information to farmers. The problems on no two farms are identical and the farmer has been encouraged to send forward his enquiries and difficulties, with regard to the management of his land and the crops for which it is best adapted, questions regarding rotations, manures and fertilizers, the breeding, care and feeding of life stock, the relative nutritive values of cattle feeds and fodders, the preparation and application of insecticides and fungicides. These and a thousand and one other matters relating to general and specialized agriculture are daily dealt with through the channel of correspondence. In this useful work of education through correspondence the Dominion Experimental Farm system may justly claim to be the pioneer. From the first and steadily all through its history it has encouraged farmers to ask for information, to make known their difficulties and the response has been remarkable. It has amply proven the wisdom of its policy. To-day throughout Canada the Experimental Farm system is regarded by thousands and tens of thousands of farmers as a reliable bureau of information, willing and prompt to help as may be practical on all occasions.

To what extent other agricultural institutions in the Dominion participate in this work I cannot say. No doubt they all have their share, but the fact that farmers may forward their letters free of postage to the Central Experimental Farm would naturally, when taken in conjunction with our widely advertised offer of help, result in the sending of the major part of the agricultural correspondence of this country for the attention of the specialists at Ottawa.

Reference must also be made to the valuable educational work accomplished by the widespread dissemination of agricultural information through the distribution of bulletins, reports, circulars, etc., from the various agricultural institutions of Canada. The number of publications so issued and sent post free on application is very large. The demand for this literature is yearly increasing, indicating not only that it is acceptable, interesting and useful, but that our farmers are readers and therefore inclined to make their heads help their hands in their everyday work. Speaking of this literature as a whole—and I can do so from the fact that the greater part has emanated from the Experimental Farm system—it has been written in plain language with the intention of imparting its information clearly and concisely and in a way understandable by the non-technical reader.

Demonstrational work is closely related to the foregoing means of disseminating information and, indeed may be regarded as a subdivision or phase of educational work proper. It is the bringing home to the farmer in a very practical way modern and approved methods in farming operations. It is the showing how, and is comparable in its object to the value and influence of the lantern slides of the lecture and the illustrations of the text book. Since their institution the farms and stations of the Dominion Experimental system and the farms connected with our agricultural colleges have in a large measure been demonstrational—that is, as regards farming methods, farm buildings, etc.—but their influence in this direction by reason of their necessarily limited number, could not be widely and intimately felt throughout all the agricultural areas of the vast Dominion. This has led in recent years to the establishment of a number of small stations here and there in the districts most needing them—demonstration stations—upon which methods of soil management in respect to the conservation of moisture, the upkeep of fertility through crop rotation and many other important phases are exemplified. These demonstration or illustration stations, although but recently established, have already exerted a marked influence on the agriculture of the districts in which they are situated. It is quite evident that in these stations we have found an additional and very valuable means of improving farming methods, and the probability is that their number

will be increased in the more difficult and more backward of our agricultural districts.

The appointment of District Representatives is a recent and important movement, inaugurated by the Province of Ontario, but rapidly copied by other provinces—it marks the latest addition to the educational and demonstrational forces of the country. The District Representative is almost invariably a graduate of an agricultural college and a man born and raised on a farm. He is one therefore who has at first hand a practical knowledge of the principles of agriculture. He is versed in modern methods. His headquarters are at some fairly large centre in an agricultural district and his work is to assist with advice and by demonstration as far as may be practical all who may apply to him. The success of a district representative will naturally depend largely on his personality, his willingness and ability to impart information and his skill as a demonstrator. Though we cannot as yet say what place in our educational system this officer may take in moulding our agriculture, there is most satisfactory evidence that in many cases he is proving an inspiration to farmers and a means of raising the general condition of agriculture. There is very much to be said in favour of the movement, for we must be all agreed that, with the right men in this work, the personal contact of the teacher and demonstrator with the farmer must result in the betterment and progress of the district from the agricultural standpoint.

In this very brief review I have only touched upon the larger and more important means bv which agricultural information of an agricultural character reaches the farmer. In concluding this phase of my address, I would say that the provisions in Canada in this connection are, on the whole, ample and excellent, and that every year sees their development and improvement. The great mass of farmers may, as yet, be outside and untouched by the influence of these educational agencies—though I should not like to endorse any such statement—but of two facts we may be well assured: that these several agencies are in the hands of well trained, able and enthusiastic men and women thoroughly imbued with the desire to help and that already may be seen the fruits of their work in profound changes for the better in the practice of Canadian agriculture.

Investigation or research in the domain of agriculture is the systematic, skilful application of the sciences—natural, physical and economic—to the solution of its problems. Its product naturally constitutes agricultural science. Its object, first, is to discover facts and secondarily is to correlate and co-ordinate them so that laws or principles may be established. Thus, successful research in agriculture adds to our definite knowledge regarding soils and crops and

livestock and enables us to propound improved methods for the conduct of the art or practice of farming. It seems clear to me that it is to agricultural science, and to this source alone, that we must look for that knowledge which can permanently advance our agricultural practice.

The problems of agriculture naturally cover a very wide field, and as a result are exceedingly varied; further, they are frequently very complex in their character. They call for profound uninterrupted and continuous study. As a rule they are difficult to solve, chiefly from the large number of factors and limiting conditions usually involved and the necessity of noting and accurately gauging their significance, before any interpretation of results can be attempted.

As in other departments, research in agriculture to be successful necessitates careful, skilful planning; there must be nothing of the haphazard in its conduct. It may proceed by experimental methods, but certainly not by a series of disconnected, unrelated experiments. It calls for a close, scrutinizing observation, clear thinking and a sound judgment, more especially in its field work, throughout its various stages and an ordered marshalling of the facts before their final interpretation. Throughout the whole work, I repeat, there must be system and scientific thoroughness, if the results are to be of permanent value and generally applicable.

I have spoken of experimental work as forming an integral part of investigation and research, for it is by experiment that we arrive at the facts, the facts necessary for the establishment of the principles. But the experimental work, taken by itself, is not necessarily of the nature of research. Isolated facts as the result, say, of field experiments, even if well proven by repeated and careful trials, seldom have any value for extended application. Much of the experimental work in agriculture to-day is of this nature, lacking scientific method, plan and completeness. The mere trying out of this and that in an indiscriminate matter, without any due regard to the laws of chemistry and biology that may be involved and without taking into account the numerous modifying factors and influencing conditions, without a study of the causes that may affect the results, while it may yield information of local importance, cannot add to the store of permanent knowledge of wide application. It is of little value for the enunciation of principles; in a word, it cannot advance agricultural science.

In saying this I do not wish to be understood as speaking derogatorarily of the agricultural experimental work of which there is so much to-day, though certainly a good deal of it might be of greater value if conducted with more care and thoroughness. It has given

and is giving important information. The point I wish to emphasize is that much of it is not profound, that it does not explain that it is limited in its value and in the application of its results, in a word, that it is not of the nature of true research. Let it be always borne in mind that the principles of agriculture, the outcome of research, are true the world over. If they do not hold good everywhere they are not principles. Rational farming methods are based on scientific principles; methods must be modified in different parts owing to the fact that conditions of soil, climate, etc., vary, but the principles upon which they are founded remain constant and permanent if they have been truly established.

For this research work we require well trained men and adequately equipped institutions. It is to the Universities alone that we can look for such men, men skilled in technique and sound in their knowledge of the sciences in which they are to labour. The broader and deeper the general education accompanying this special training the better prepared will the research worker be to cope with the many-sided problems that will continually present themselves. Some first hand knowledge of farm operations is most desirable to avoid pitfalls, but this can be obtained prior to or after the college course. As in other lines of investigatory work, a special aptness for or love of the work is, I believe, a great advantage, as is also the power of concentration and withal patience. We can scarcely expect the greatest measure of success without these qualities.

One of the objects that I had in mind in preparing this address was to call attention to the fact that our more important Universities have not as yet taken any leading or special part in this truly national work towards the improvement of Canadian agriculture, unless we consider as such their affiliation with the agricultural colleges—colleges situated at a considerable distance and not assisted in any way by the University science staffs. So far as I can see Canadian Universities have taken little cognizance of agricultural research, either in their undergraduate or postgraduate work—that is, if we except forestry, which is certainly to be regarded as a branch of agricultural science. This is exceedingly strange to me and a state of affairs that surely must have arisen from a lack of appreciation of the true character of agricultural science. It is scarcely necessary to remind you that research work in agriculture demands as deep and thorough knowledge of the natural and physical sciences as does other scientific research, as for instance medicine. Personally, I am very anxious that our Universities should make some provision for agricultural science on their curricula.

It is not my intention now to indicate how this may best be done, much less to dictate the steps to be taken by our Universities that within their halls agricultural sciences may be adequately recognized. I feel assured that if the governing bodies once realize that agricultural research work is worthy of university men—and their best men—ways and means will be forthcoming to find a place for it on their curricula.

In the mean time, there is one matter that I should like to emphasize; it relates more particularly to the work I am personally interested in—chemical work. It is the desirability of greater care and thoroughness in the teaching of analytical chemistry at our universities. I speak feelingly on this subject. Perhaps it is that this branch of chemistry is relegated to juniors who themselves are not well trained; possibly the classes are too large for close supervision and the individual guidance of its members, or possibly that analytical chemistry is not the vogue of to-day or thought very highly of in our universities as a part of a chemical education and therefore somewhat neglected. But whatever the cause, the fact remains that the larger numbers of our honour graduates in chemistry as they leave college are miserable analysts. They give little evidence of having been carefully trained in technique and manipulation. Their use and handling of apparatus and the conduct of analytical work is far from satisfactory. We ought to expect from these men a knowledge of correct methods in weighing, filtering, incinerating, the use of volumetric apparatus, the making and putting together of simple apparatus, and other every-day laboratory operations in analytical work, but they work as if they had "picked up" all the knowledge they have on such matters. The graduates of the English and Scottish Universities, I am sorry to say it, exhibit much better training; at least that is my experience. Reliable results, I am confident, cannot be obtained from sloppy, slipshod manipulation. In agricultural research work extreme accuracy is required—the highest accuracy obtainable. In this, I presume, it differs from much control work in manufacturing concerns. An error of ·02 per cent in the amount of available potash in a soil may throw us all astray in the interpretation of the data. We do not expect from our recent graduates a knowledge of special methods used in agricultural work, but we do expect that the men sh ·'d be able to perform correctly and fairly rapidly and with good t que those operations which form a part of all analytical procedure. And, if I may be permitted to say it, to give the men a hurried course of a fortnight or so towards the close of the college term in which a soil, a fertilizer, a cattle food and a dairy product is "put through" is worse than useless. The experience is . d, for it means

faults to be corrected once research work is entered upon, and much time is lost. Analytical work is an intellectual work, and it should be so regarded by those teaching it in our universities, but it should also be taught as a fine art in which correct technique counts largely in the value of the results. It seems to me that in the making of a good analyst it is just as important to pay attention to technique as it is in the training of the piano student who would later on hope to correctly interpret a Bach fugue or a Beethoven sonata.

As to institutions in which this work is to be carried on, we have first, of course, the Dominion Experimental Farm system, and secondarily, to some degree at least, the larger and better equipped of our Agricultural Colleges. If the work is to be restricted to these institutions it will be necessary to give them the means and men for the necessary development. There is a great deal of work ahead of us in this field. To the universities, I offer the consideration of establishing fellowships and post-graduate courses in agricultural science. This surely would not be impossible. There are many problems eminently suited to the conditions obtaining at several of our larger universities, which could furnish subjects for post-graduate work.

And I have also in mind the desirability of the establishment of a Canadian Institute of Agricultural Research, wherein the more abstract and difficult problems of agriculture could be patiently and uninterruptedly studied. Other countries have such institutions and the value of their work has amply justified the expenditure. It is a big project, but not too big for Canada. Under the joint control of the Government and the universities such an institution could do a most valuable national work. The day will come, I think, when we shall favourably consider the establishment and endowment of such an institution. It would be a worthy object and a useful channel for the appropriation of public funds, unless it be, in the meantime, that it has attracted private benefaction. What more splendid memorial could be erected by those, who, having the means, wish to leave a legacy ever increasing in value to their country, one that in its assistance to our national industry, could forward the development and the welfare of the Dominion.